

# Coastal Modeling System

## *Advanced Topics*



**Alex Sánchez**

*Research Hydraulic Engineer*

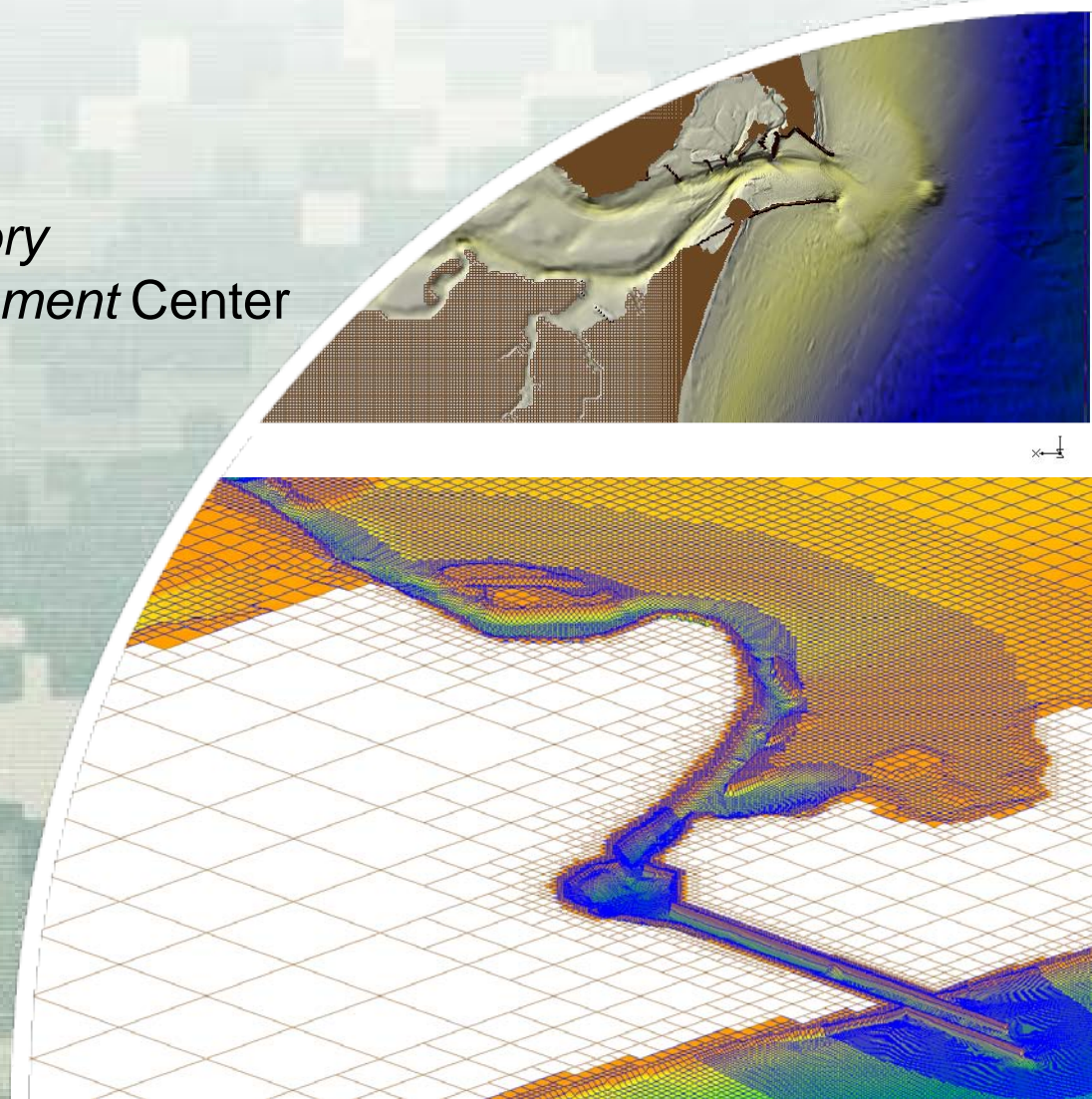
*Coastal and Hydraulics Laboratory*

*Engineer Research and Development Center*

June 18, 2012



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# Webinar Outline

## ▪ **18 June 2012 - Day 1**

- Introduction to CMS (slides)
- Overview of Documentation and Workshop Material – Read it!
- Tips for preparing bathymetry and other scattersets
- Tips for setting up and running
- Hydrodynamics

## ▪ **19 June 2012 - Day 2**

- Initial and Boundary Conditions
- Salinity Transport
- Surface Roller

## ▪ **20 June 2012 – Day 3**

- Sediment Transport

## ▪ **21 June 2012 - Day 4**

- Numerical Methods
- Advanced Output
- Scripting

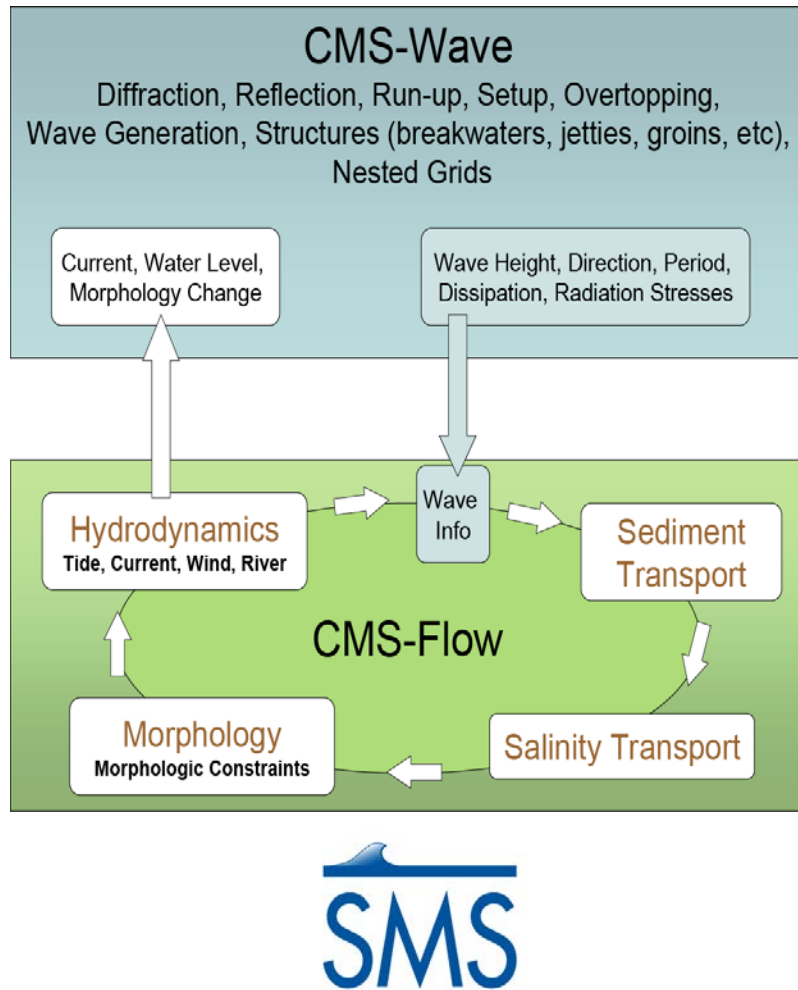
## ▪ **22 June 2012 - Day 5**

- Debugging and Problem solving
- Model Calibration
- Post-processing

# Focus of Workshop

- Not a hands-on tutorial (SMS experience assumed)
- Where and how to find documentation, tutorials, etc
- Theory and numerical methods
  - Model applicability
    - Knowing when and when not to use CMS before you start.
  - Interpreting results
    - So the model ran, now what?
  - Calibration
    - “To reproduce nature you must understand it.”
  - Designing cases or alternatives and making engineering decisions
    - While keeping it real.
- Tips on how to setup, run, and analyze results
  - Effectively:
    - The end result is sufficiently correct or adequate for the purposes of the project
  - Efficiently:
    - The setup process is fast and without wasted time or effort





## What is the CMS?

Integrated wave, current, and morphology change model in the Surface-water Modeling System (SMS).

## Why CMS?

Operational at 10 Districts  
Validated with real applications  
Robust and user-friendly  
Practice-oriented:  
*1 year simulation ~ 1-3 days on PC*

## Types of Applications

**Channels:** Deepening, widening, lengthening, realigning  
**Jetties:** Lengthening, raising, rehabbing  
**O&M:** Placement areas – berms, wetlands  
**Processes:** *Navigability* – waves and currents; *Environmental* – circulation, and sediment transport

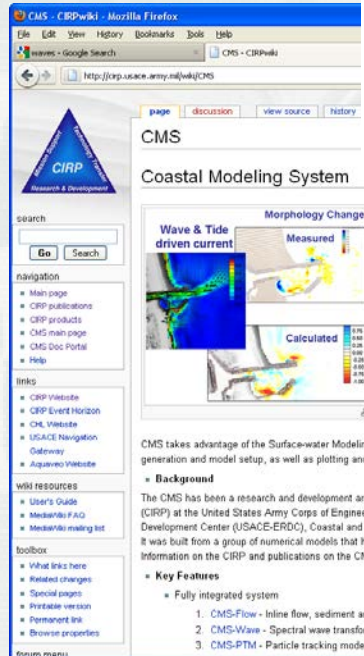
# Coastal Modeling System

## Coastal Modeling System Overview, background and capabilities

Alex Sánchez  
Research Hydraulic Engineer  
Coastal and Hydraulics Laboratory  
Engineer Research and Development Center  
May 20, 2010



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### Exporting the bottom friction dataset

Exporting the bottom roughness (friction) datasets is useful for creating different project alternatives or when switching from different bottom roughness datasets types such as from Manning's  $n$  to Bottom Friction Coefficient and back. It is also useful for scripting multiple runs with different project alternatives.

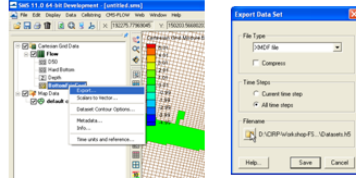


Figure 5.1.12. Manning's  $n$  contours after modifying the areas under all three bridges.

### Additional Bottom Friction Cards

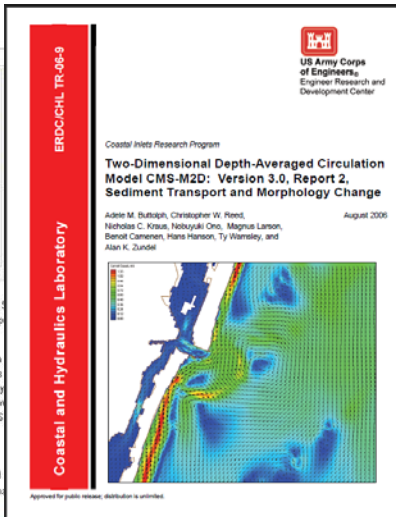
Additional advanced cards are available for setting the bottom friction to a constant for the whole grid. These cards are useful for running sensitivity analysis for a wide range of values in cases which can be approximated with a single constant bottom friction value.

Table 5.1.2. Advanced Cards: to set bottom friction dataset to a constant value

Card	Argument	Default	Range	Description	CMS Variable
MANNING_N_CONSTANT	real number	0.05	0.05 - 0.15	Specifies a constant input Manning's $n$ coefficient. Overrides any previous bottom friction cards.	MAN_N
BOTTOM_FRICTION_COEFF_CONSTANT	real number	0.05	0.05 - 0.15	Specifies a constant input Bottom Friction Coefficient. Overrides any previous bottom friction cards.	BOT_FRI
ROUGHNESS_WEIGHT_CONSTANT	real number	0.05	0.05 - 0.15	Specifies a constant Roughness Weight in $\text{m}^2$ . Overrides any previous bottom friction cards.	ROUGHNESS

### 5.1.2 Wall Friction

The wall friction enhances the flow drag perpendicular to any dry boundary. The wall friction may be turned On or Off in the Flow tab of the CMS-Flow Model Control.



## Availability

- Comes with SMS installation package
- CIRP website (under Products)
- CMS is **Free**, interface is relatively inexpensive

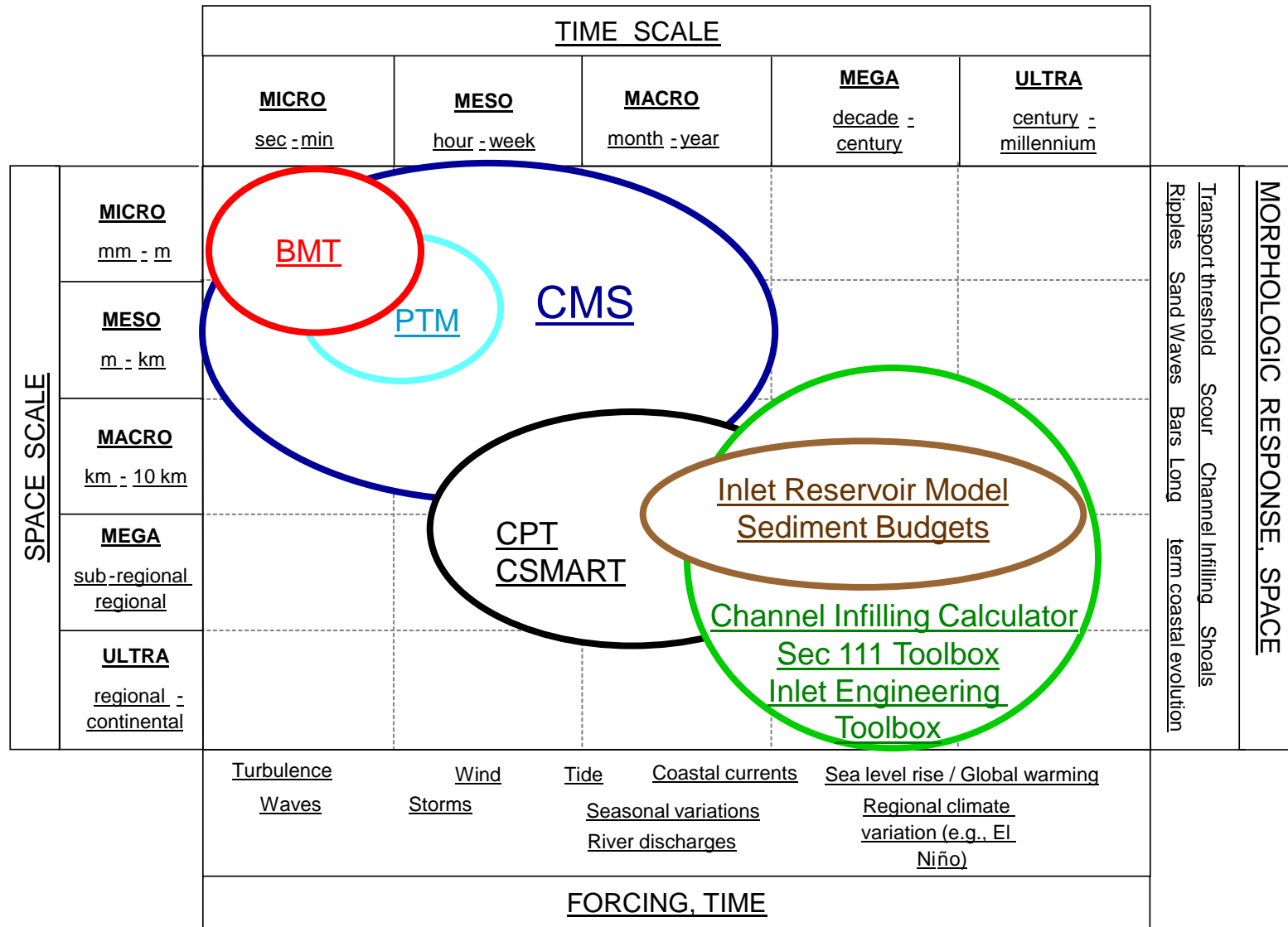
## Documentation

- Several TR's, CHETN's and journal papers
- CIRP Wiki  
<http://cirp.usace.army.mil/wiki/CMS>
- New Tech Report will be available later this summer

## Training and Support (**Free**)

- Tech Transfer Workshops (32 since 1997)
- Additional workshops by request
- On-site training
- Seminars
- Step-by-step instructional material
- Webinars

# Scales of Coverage

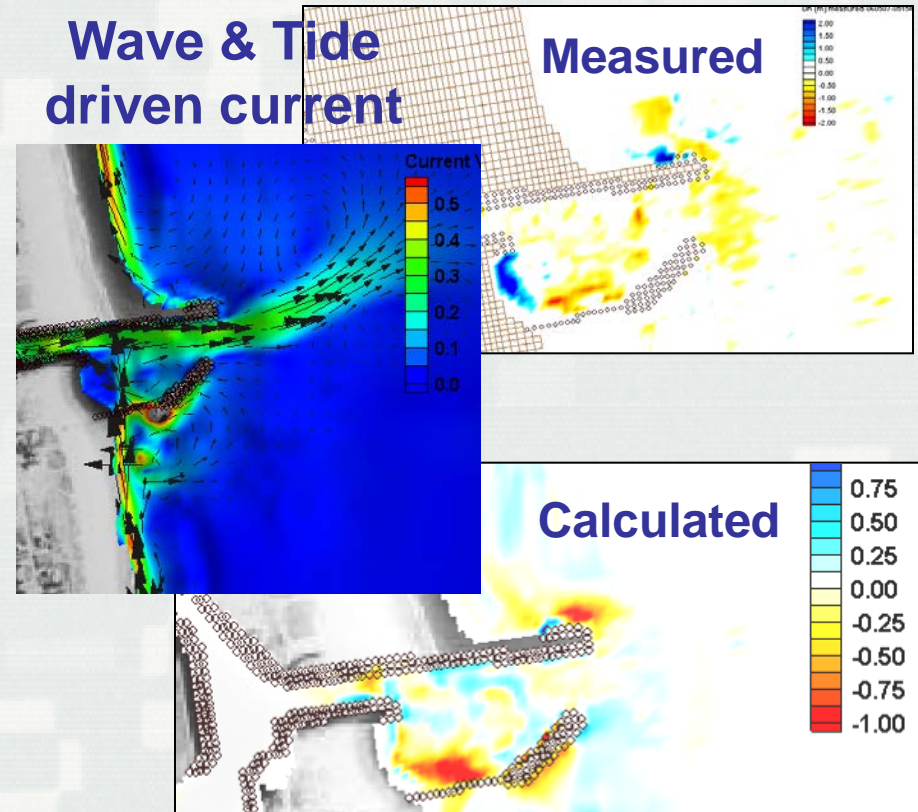




# CMS-Flow Key Features

- Finite Volume Method
  - Conserves mass
  - Stable
  - Accessible
- Coupled with spectral wave model (CMS-Wave)
  - Wave-current interactions
- Inline sediment transport and morphology change
  - Non-equilibrium sediment Transport model (NET)
- Nesting capability
- Tide, river, wind, atm. pres., forcing
- Integrated Particle Tracking Model (CMS-PTM)

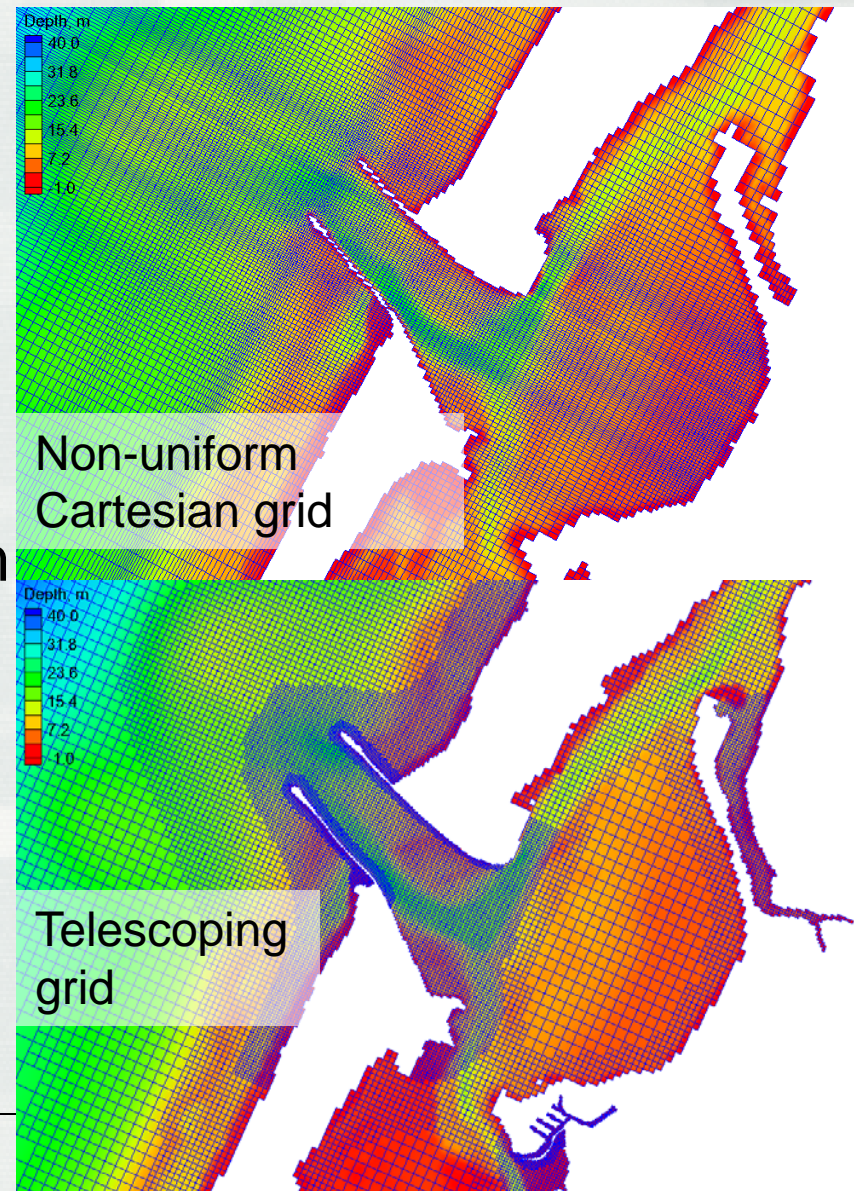
**Wave & Tide  
driven current**



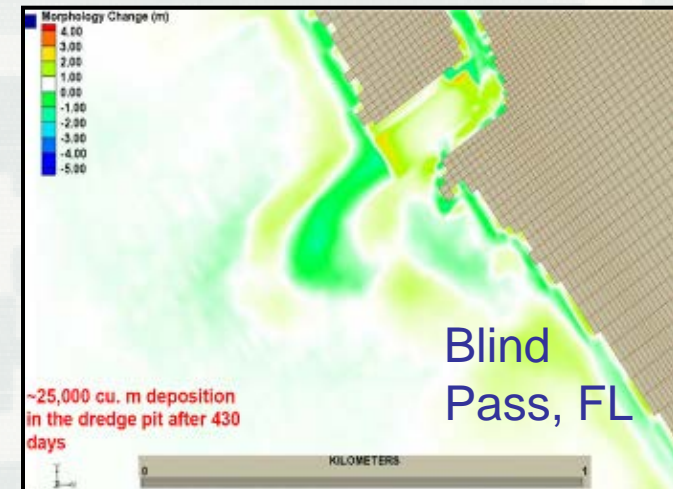
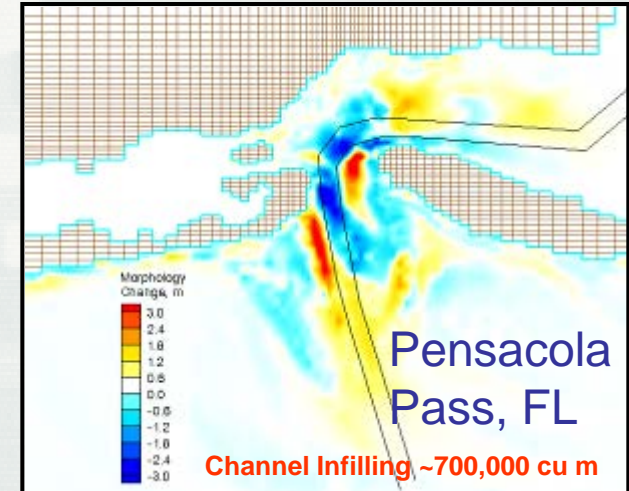


# CMS-Flow Key Features

- Grid options
  - Non-uniform Cartesian grid:  
Easy to setup
  - Telescoping grid:  
Efficient and flexible
- Solver options
  - Implicit: Tidal flow, long-term morphology change. ~10 min time step
  - Explicit: Flooding, breaching, super-critical flow. ~ 1 sec time step
- Parallel Processing



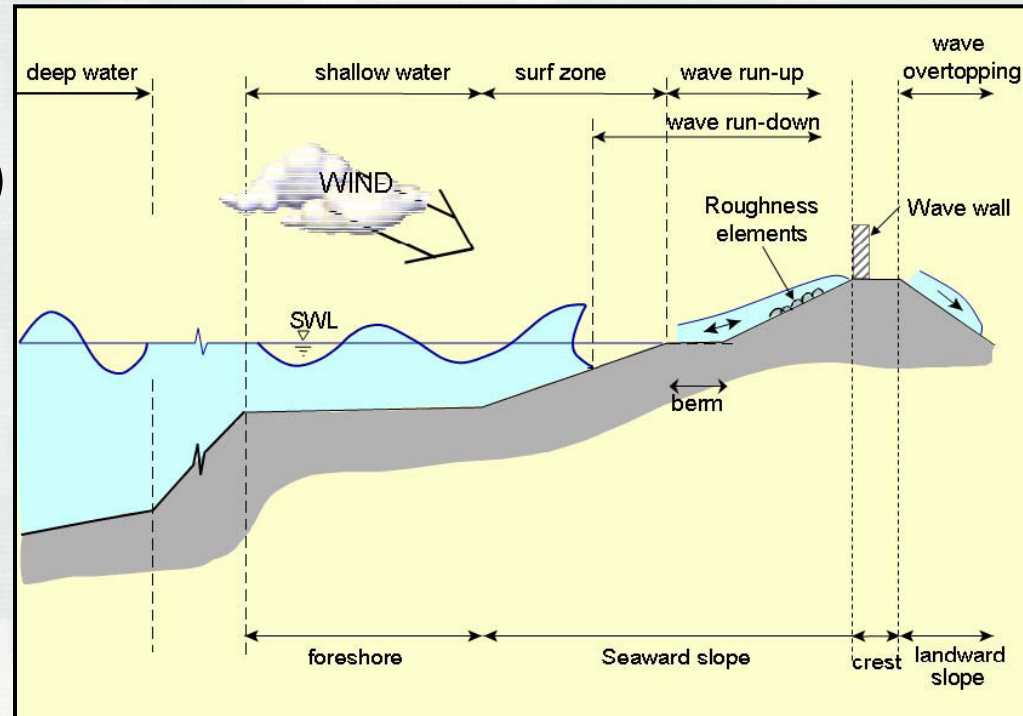
- Sediment transport models
  - Equilibrium Total Load (Exner equation)
  - Eq. Bed Load + AD Suspended Load
  - Non-Eq. (AD Total Load)
- Sediment transport formulas
  - Lund-CIRP
  - Van Rijn
  - Watanabe
  - Soulsby-van Rijn
- Hard-bottom
- Avalanching
- Bed slope influence on bed load
- Multiple-sized sed. transport





# CMS-Wave: Key Features

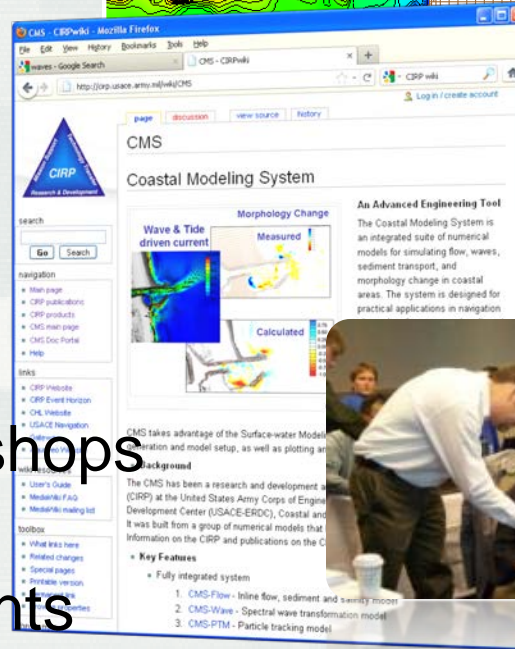
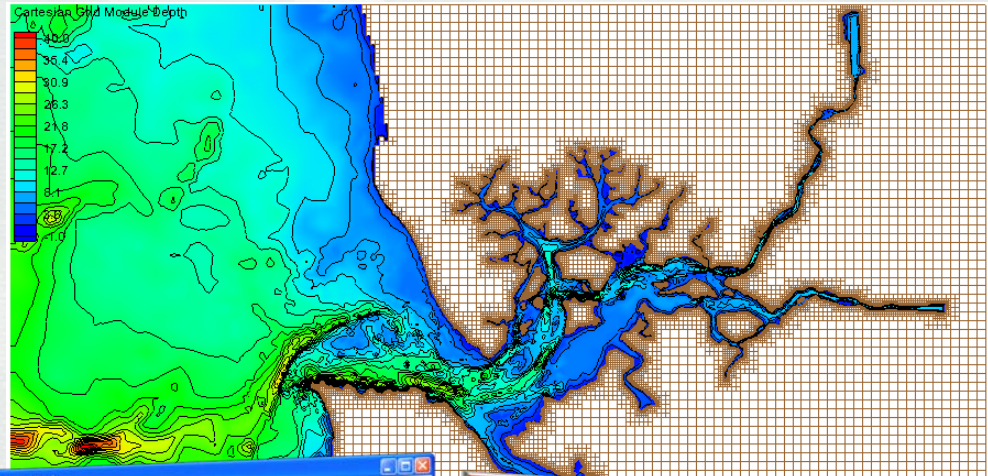
- Shoaling, refraction, diffraction, reflection
- Bottom friction
- White capping
- Wave breaking (4 options)
- Wind generation
- Wave-current, and wave-wave interactions
- Transmission, runup and overtopping
- Muddy bottom
- Automatic grid rotation
- Non-uniform Cartesian grid with nesting capability
- “Fast Mode”





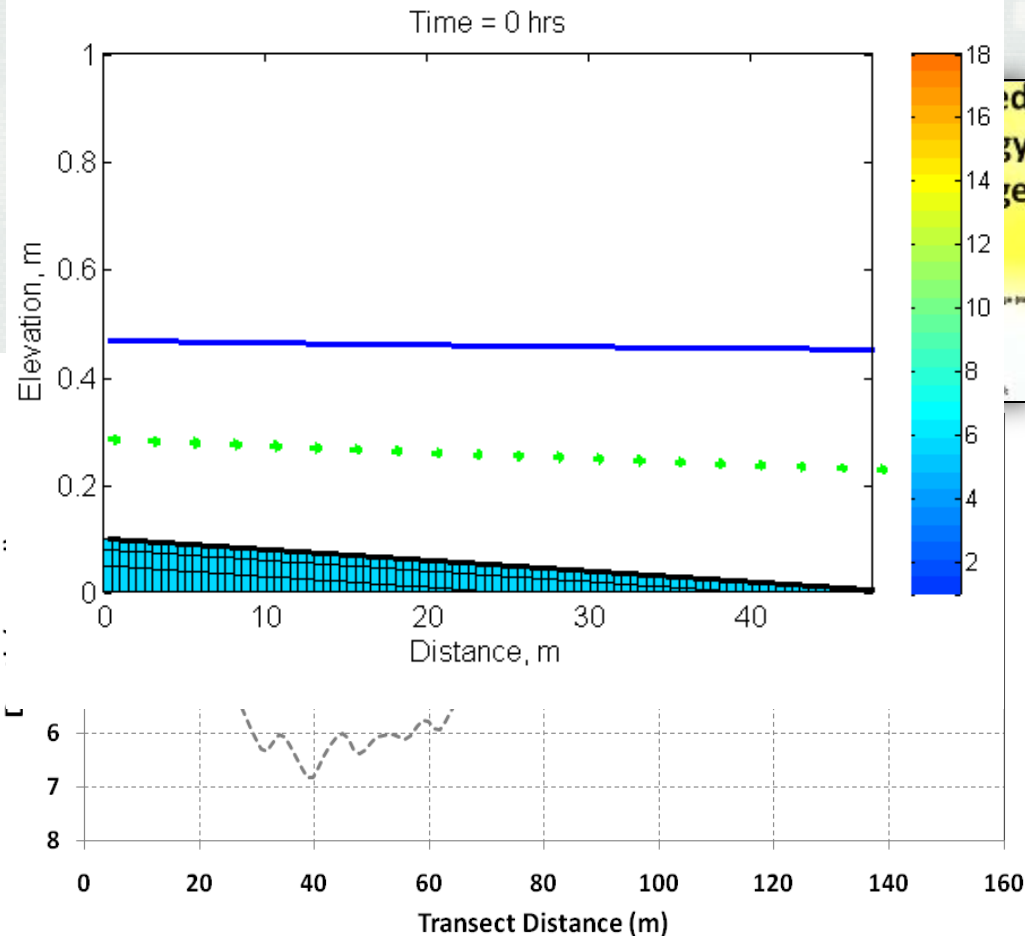
# Recent Accomplishments

- New features
  - Telescoping grid
  - Multiple-sized sed transp
  - Surface roller
  - Wave-averaged formulation
  - Cross-shore sed transp
    - CSHORE & Lund-CIRP
- 6 Journal papers
- 5 Conference papers
- 2 V&V TR's
- 6 Wiki-TN's
- 1 PTM CHETN
- 2 CMS & 1 ADH Workshops
- Physical experiment
- R&D in graded sediments



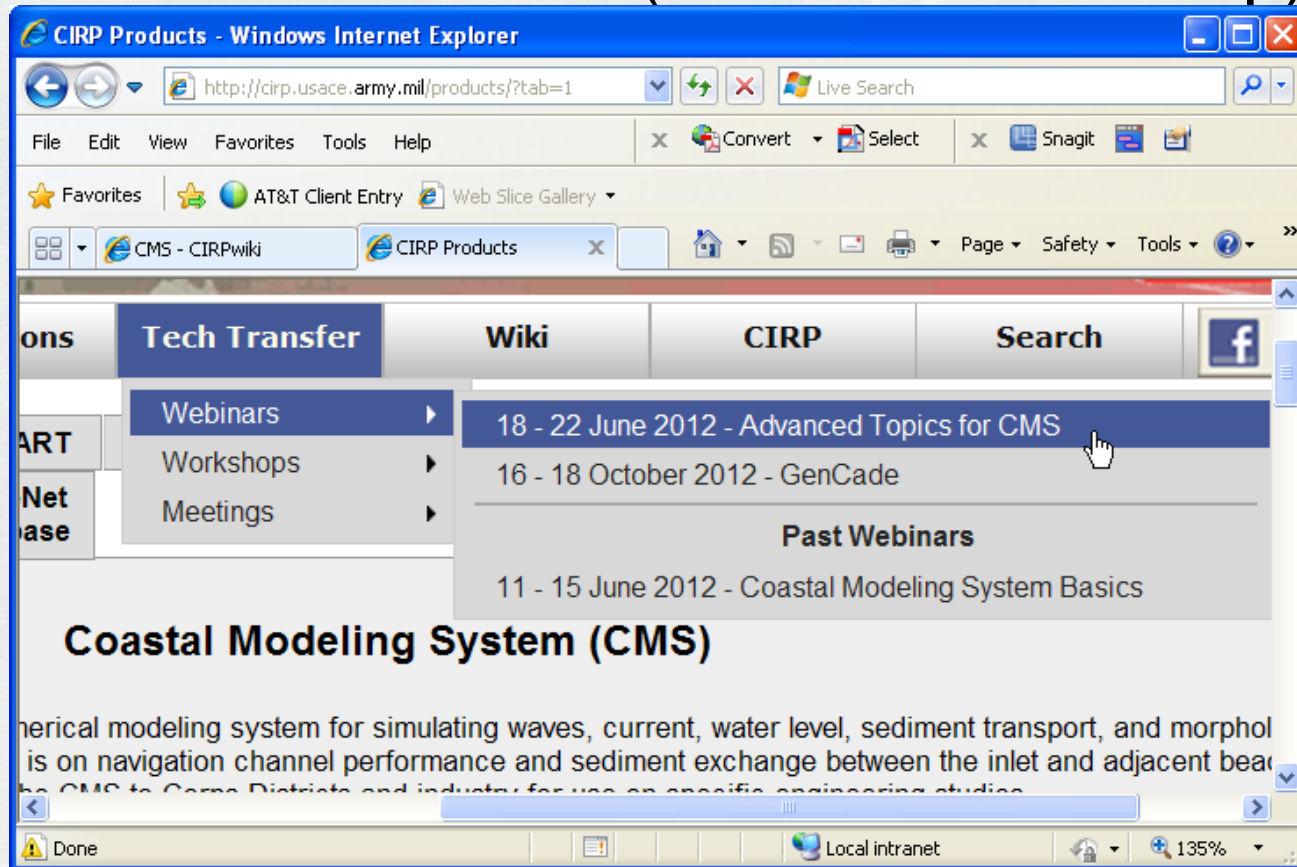
# Verification and Validation Reports

- Provides benchmark data sets and performance with which to evaluate other coastal models
- Applies unambiguous criteria in evaluation of model calculations via goodness-of-fit statistics
- Provides a go-by for applications to similar coastal projects and problems
- Identifies areas for future data collection and research
- Data and draft reports will be posted on CIRP website



# Workshop Material

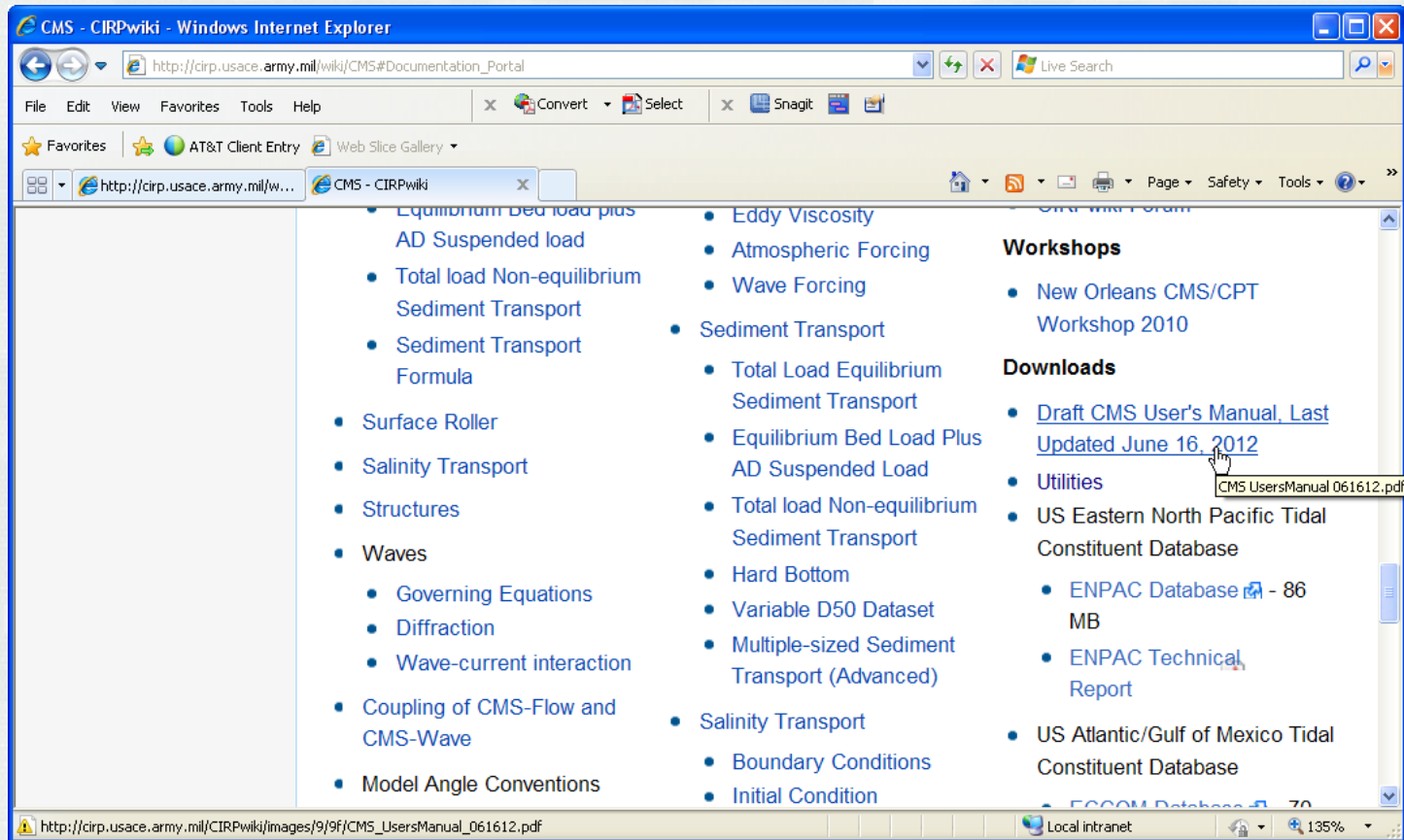
- CMS-Flow data folder (same as workshop)



<http://cirp.usace.army.mil/workshops/nap12/NAP-Workshop.html>



# Draft CMS User Manual



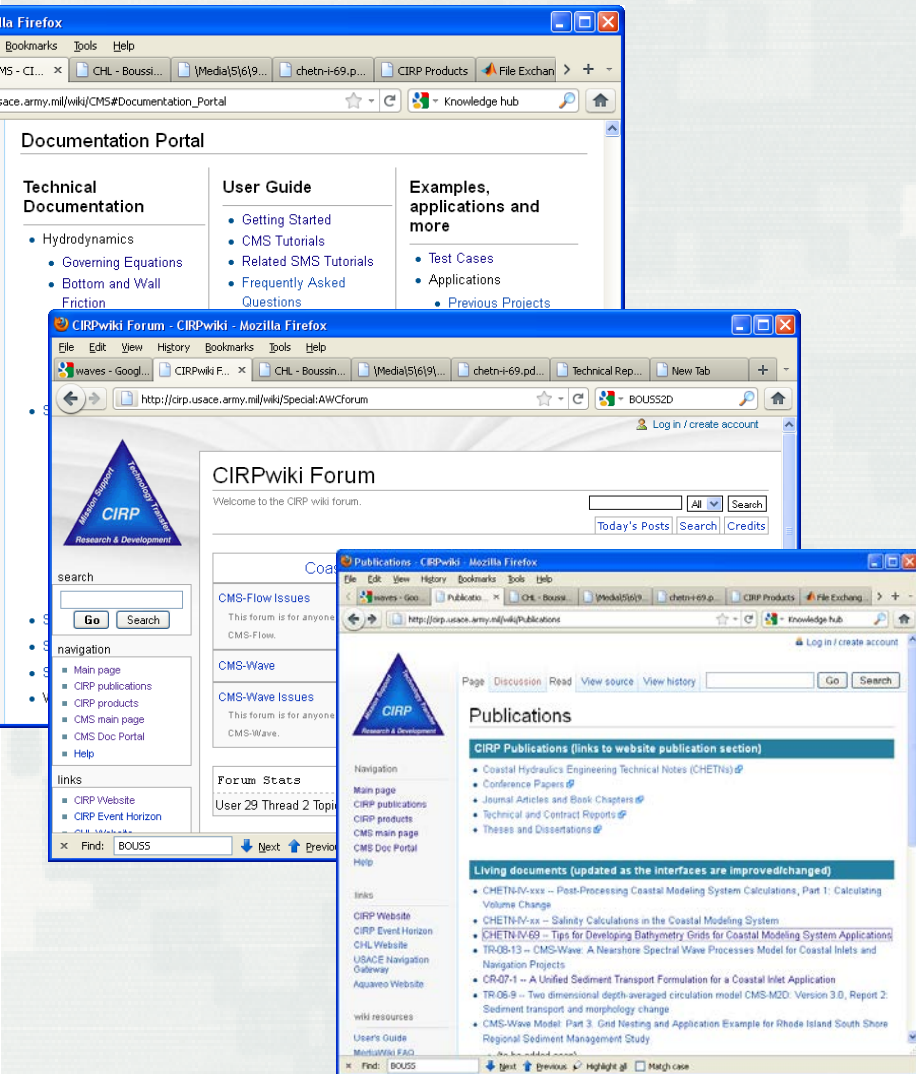
<http://cirp.usace.army.mil/wiki/CMS>

# CIRP Websites



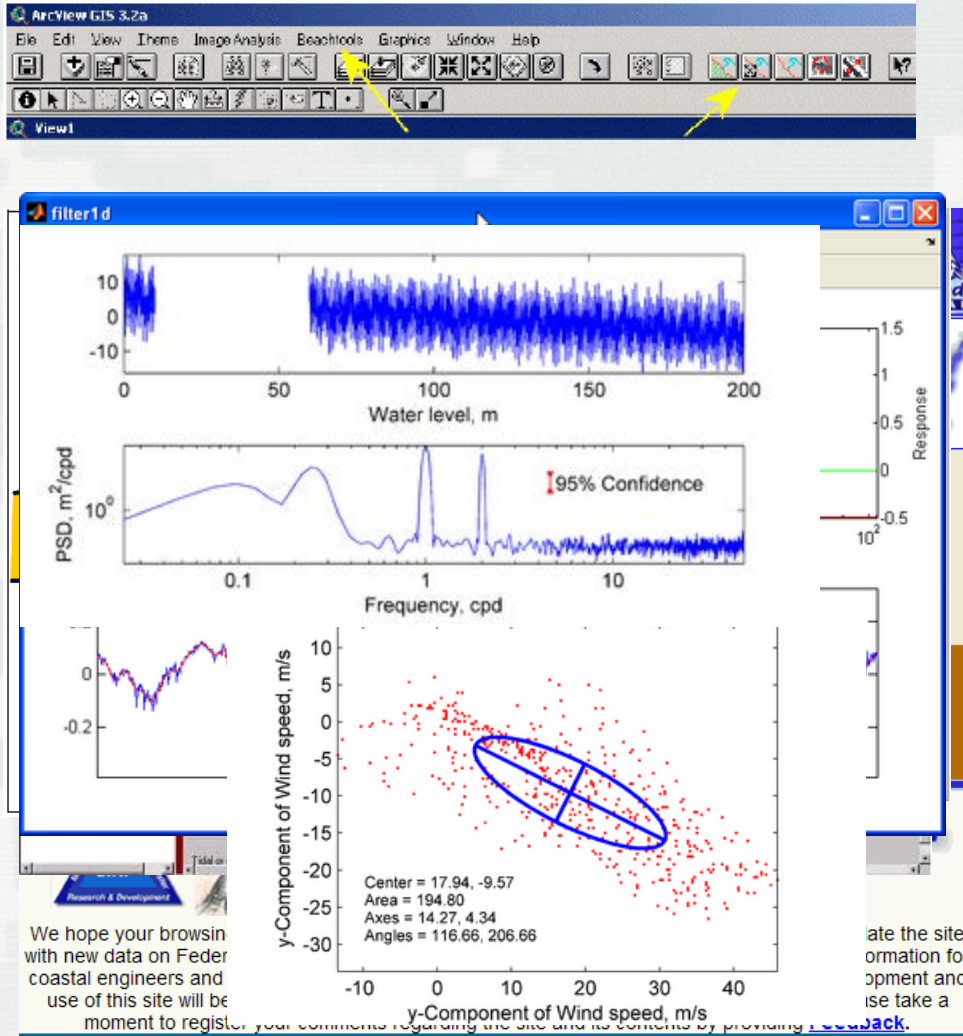
60 CIRP documents published as eBooks

- 183 Content Pages
- >75,00 views
- Documentation Portal
  - Technical Documents
  - User Guide, tutorials, user-interface, guidance
  - Test cases
- Forum
- Links to CIRP website, publications, products, etc





# Other Products and Tools



- Beach Tools
- Inlets Online
- Inlet Reservoir Model
- Channel Equilibrium Area
- Tidal Analysis and Prediction Software
- Filter1D : Time Series Analysis Tool
- Utilities for pre- and post-processing, data analysis and plotting (e.g. HyPAS)
- Downloadable from CIRP website or Wiki

CIRP Publications - Windows Internet Explorer

http://cirp.usace.army.mil/pubs/

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**US Army Corps of Engineers**  
**CIRP - Coastal Inlets Research Program**

**Publications** **Tech Transfer** **Wiki** **CIRP**

## CIRP Publications

[Coastal Hydraulics Technical Notes \(CHETNs\)](#) **NEW**

[Conference Papers](#)

[Journal Articles](#) **NEW**

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Research & Development

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# Reports and Tech Notes

- Sánchez, A., Wu, W. Rosati, J.D., Demirbilek, Z. Li, L., Rosati, J., Thomas, R., Reed, C., Watts, I., and Brown, M. 2011. **Validation of the Coast-al Modeling System: Report III, Hydrodynamics.** *Tech. Report ERDC/CHL-TR-11-10, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS.*
- Sánchez, A., Wu, W. Rosati, J.D., Demirbilek, Z. Li, L., Rosati, J., Thomas, R., Reed, C., Watts, I., and Brown, M. 2011. **Validation of the Coastal Modeling System: Report IV, Sediment Transport and Morphology Change.** *Tech. Report ERDC/CHL-TR-11-10, US Army Engineer Research and Development*
- Demirbilek, Z., K. J. Connell, N. J. MacDonald, and A. K. Zundel. 2008. **Particle Tracking Model in the SMS 10: IV. Link to Coastal Modeling System.** Coastal and Hydraulics Engineering Technical Note ERDC/CHL CHETN-IV-71. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
- Brown, M. E., and N. C. Kraus. 2007. **Tips for developing bathymetry grids for Coastal Modeling System Applications,** Coastal and Hydraulics Laboratory Engineering Technical Note ERDC/CHL CHETN-IV-69. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
- Buttolph, A. M., Reed, C. W., Kraus, N. C., Ono, N., Larson, M., Camenen, B., Hanson, H., Wamsley, T., and Zundel, A. K. 2006. **Two-Dimensional Depth-Averaged Circulation Model CMS-M2D: Version 3.0, Report 2, Sediment Transport and Morphology Change,** Technical Report ERDC/CHL-TR-06-7, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, Mississippi.
- Lin, L., Z. Demirbilek, H. Mase, J. Zheng., and F. Yamada. 2008. **CMS-Wave: A Nearshore Spectral Wave Processes Model for Coastal Inlets and Navigation Projects.** ERDC/CHL TR-08-13.
- Lin, L., H. Mase, F. Yamada, and Z. Demirbilek. 2006. **Wave-Action Balance Equation Diffraction (WABED) Model: Tests of Wave Diffraction and Reflection at Inlets.** ERDC/CHL CHETN-III-73.



- Sánchez, A., and Wu, W. 2010. **"A Non-equilibrium Sediment Transport Model for Coastal Inlet Applications"**. *Journal of Coastal Research*, Submitted Oct 2009.
- Camenen, B., and Larson, M., 2008. **"Equivalent Roughness Height for Plane Bed Oscillatory Flow,"** *Estuarine, Coastal, and Shelf Science*, Vol 81, pp 409-422.
- Camenen, B., and Larson, M., 2008. **"A General Formula for Non-Cohesive Suspended Sediment Transport,"** *Journal of Coastal Research*, Vol 24, No. 3, pp 615-627.
- Camenen, B., and Larson, M. 2007. **"A Unified Sediment Transport Formulation for Coastal Inlet Application,"** Contract Report ERDC/CHL-CR-07-1, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, Mississippi.
- Camenen, B., and Larson, M. 2007. **"A Total Load Formula for the Nearshore,"** *Proceedings Coastal Sediments '07 Conference*, ASCE Press, Reston, VA, 56-67.
- Hanson, H., and Camenen, B. 2007. **"Closed Form Solution for Threshold Velocity for Initiation of Sediment Motion Under Waves,"** *Proceedings Coastal Sediments '07 Conference*, ASCE Press, Reston, VA, 15-27.
- Camenen, B. and Larson, M., 2006. **"Phase Lag Effects in Sheet Flow Transport,"** *Coastal Engineering*, Vol 53, pp 531-542.
- Camenen, B., Bayram, A., and Larson, M., 2006. **"Equivalent Roughness Height for Plane Bed Under Steady Flow,"** *Journal of Hydraulic Engineering*, Vol 132, No. 11, pp 1146-1158.
- Gravens, M. B., and Wang, P. 2007. **"Data Report: Laboratory Testing of Longshore Sand Transport by Waves and Currents; Morphology Change Behind Headland Structures,"** Technical Report ERDC/CHL-TR-07-8, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, Mississippi.

# Publications: Applications/Projects

- Beck, T.M., and Wang, P. 2009. **Influences of channel dredging on flow and sedimentation patterns at microtidal inlets, West-central Florida, USA.** Proceedings Coastal Dynamics 2009.
- Li, H., Brown, M. E., Smith, T. D., Podoski, J. H., 2009 (draft). **Evaluation of Proposed Channel on Circulation and Morphology Change at Kawaihae Harbor and Pelekane Bay, Island of Hawaii, HI,** Technical Report ERDC/CHL-TR-XX-XX, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS.
- Seabergh, W.C., Smith, E.R., and Rosati, J.D. 2009 (draft). **Sabine-Neches Waterway, Sabine Pass Jetty System: Past and Future Performance,** ERDC/CHL-TR-09-X, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS
- Demirbilek, Z., Lin, L., and Nwogu, O. G. 2008. **Wave Modeling for Jetty Rehabilitation at the Mouth of the Columbia River, Washington/Oregon, USA,** ERDC/CHL-TR-08-3, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, Mississippi.
- Barcak, R. G., Kraus, N. C., Lin, L., Smith, E. R., Heilman, D. J., and Thomas, R. C. 2007 **Navigation Improvement, Mouth of the Colorado River, Texas,** *Proceedings Coastal Sediments '07 Conference*, ASCE Press, Reston, VA, 1502-1514.
- Wang, P., Tidwell, D. K., Beck, T. M., and Kraus, N. C. 2007. **Sedimentation Patterns in a Stabilized Migratory Inlet, Blind Pass, FL.** *Proceedings Coastal Sediments '07 Conference*, ASCE Press, Reston, VA, 1377-1390.
- Zarillo, G. A., and Brehin, F. G. A. (2007) **Hydrodynamic and Morphologic Modeling at Sebastian Inlet, FL,** *Proceedings Coastal Sediments '07 Conference*, ASCE Press, Reston, VA, 1297-1310.
- Wamsley, T. V., Cialone, M. A., Connell, K. J., and Kraus, N. C. 2006. **Breach History and Susceptibility Study, South Jetty and Navigation Project, Grays Harbor, Washington,** ERDC/CHL-TR-06-22, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS.
- Hughes, S. A., and Cohen, J. 2006. **Half Moon Bay, Grays Harbor, Washington: Movable-Bed Physical Model Study,** Technical Report ERDC/CHL-TR-06-15, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS.



# Publications: Various

- Nam, P.T., and Larson, M. 2010. **Model of nearshore waves and wave-induced currents around a detached breakwater**, *Journal of Waterway, Port, Coastal, and Ocean Engineering*, 136(3),156-176.
- Wu, W., Sánchez, A., and Mingliang, Z., 2010. **An Implicit 2-D Shallow Water Flow Model on an Unstructured Quadtree Rectangular Grid**, *Journal of Coastal Research*, Submitted Oct 2009
- Nam, P.T., Larson, M., Hanson, H., and Hoan, L.X. 2009. **A numerical model of nearshore waves, currents, and sediment transport**, *Coastal Engineering*, 56, 1084-1096.
- Demirbilek, Z., Lin, L., Seabergh, W.C., Mase, H., and Zheng, J.I. 2009. **Laboratory and Numerical Studies of Hydrodynamics Near Jetties**, *Coastal Engineering Journal* Vol. 51, No. 2, 143-175.
- Sánchez, A. 2008. **Interactions between wetlands and tidal inlets**, *Coastal and Hydraulics Engineering Technical Note*. ERDC/CHL CHETN-IV-72. Vicksburg,MS: U.S. Army Engineer Research and Development Center.
- Seabergh, W. C., Demirbilek, Z., and Lin, L. (2008). **Guidelines Based on Physical and Numerical Modeling Studies for Jetty Spur Design at Coastal Inlets**, *International Journal of Ecology & Development (IJED)*, Vol. 11, No. F08, pp 4-19.
- Zheng, J., H. Mase, Z. Demirbilek, and L. Lin. 2008. **Implementation and evaluation of alternative wave breaking formulas in a coastal spectral wave mode**. *Ocean Engineering*. Vol. 35., pp.1090-1101.
- MacDonald, N. J., Davies, M. H., Zundel, A. K., Howlett, J. D., Demirbilek, Z., Gailani, J. Z., Lackey, T. C., and Smith, J. (2006). **PTM: Particle Tracking Model; Report 1: Model Theory, Implementation, and Example Applications**, Technical Report ERDC/CHL-TR-06-20, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, Mississippi.



- Decent text editor such as Textpad, UltraEdit, NotePad++, etc.
  - For viewing and editing large ASCII files
- HDFView
  - For viewing and editing XMDF files
- Matlab or Octave (free)
  - For pre-processing, post-processing, data analysis, and visualization.
- Excel is ok, but don't use it for everything (yes you)
- Good computing machine

# Questions?

Alejandro Sanchez

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*Thanks to the CIRP team and developers:*